



A SENSITIVE INSTRUMENT FOR MEASURING WIRE TENSION
IN MULTIWIRE PROPORTIONAL AND DRIFT CHAMBERS*

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in Multiwire Proportional and Drift Chambers.

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Introduction

We describe a device that is capable of detecting and displaying the resonant frequency of wires in open or closed, proportional and drift chambers.

It is necessary to verify that all wires in these detectors fall within an acceptable tension range and to ensure a uniform response to electrostatic effects when the high voltage is applied to the chamber.¹

Previously, the method employed consisted of using high-output voltage audio frequency oscillators driving a wire which had been placed in a magnetic field. At resonance the wire would vibrate visibly and the tension could be determined as a function of this frequency.²

There are several drawbacks to this system:

1. High audio voltages and their requisite currents can heat the wire which is quite often near the point where it becomes plastic, or stretches.
2. The large physical movement required to observe the resonance can conceivably weaken the wire.
3. The chamber must be open to observe these effects.
4. Often a chamber sustains stress both structurally and thermally in the process of opening in a suitable environment.
5. It is difficult to determine, with wires of less than 1 mil whether connection is made or not.

A method has been described to determine the resonant frequency of chambers in their operational environment, but used discrete instruments and did not address the additional problems encountered in testing these chambers.³

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Theory

Once the resonant frequency is determined with the instrument, the tension of the wire can be derived using the following relationship between frequency and tension.

$$T_{gr} = \frac{4 v^2 l^2 \rho A}{\mu^2 980}$$

where:

l = length (cm)

A = cross sectional area (cm²)

ρ = density of wire material (g/cm³)

μ = 1 for these calculations

v = frequency (Hz)

Gold plated tungsten of 1.5 mil diameter has a ρ of 19.3 g/cm³ and beryllium-copper of 4 mil diameter has a ρ of 8.96 g/cm³.

Description

The wire-tension tester consists of a audio oscillator exhibiting high stability followed by simple pass-band filters and an output section driving a primitive current source.

The frequency readout consists of a four digit frequency counter utilizing the A.C. line frequency processed so as to be a clock for a one or ten second gate. The ten second gate is used to facilitate accurate counting, if needed. Time period averaging could have been employed, however it was considered too complex for the task at hand. For average use, counting to the hertz level is all that is necessary.

A continuity circuit is employed across the current source to audibly indicate if connection to the wire is complete. This is extremely useful since connecting to the wires is difficult owing to the small diameters involved and valuable time has been lost looking for resonance indications when, in fact, the instruments simply were not connected.

An analogue readout is employed to indicate visually, when the resonant frequency is reached. Since this testing is quite often accomplished in hostile environments, it soon became obvious that it

was necessary to reject, or at least minimize the effects thereon of all noise, including the incident signal, and to measure only that signal which is generated by the motion of the wire in the magnetic field. This was accomplished by using an extremely high gain amplifier in an adjustable bridge configuration across the output terminals.

Operation

Using the instrument is relatively uncomplicated. Since the Q of these mechanical systems is extremely high, it is necessary to know what the frequency should be in advance. M. Atac and M. Mishina³ have demonstrated that the resonance curve of a typical wire has a FWHM of less than 1 Hz.

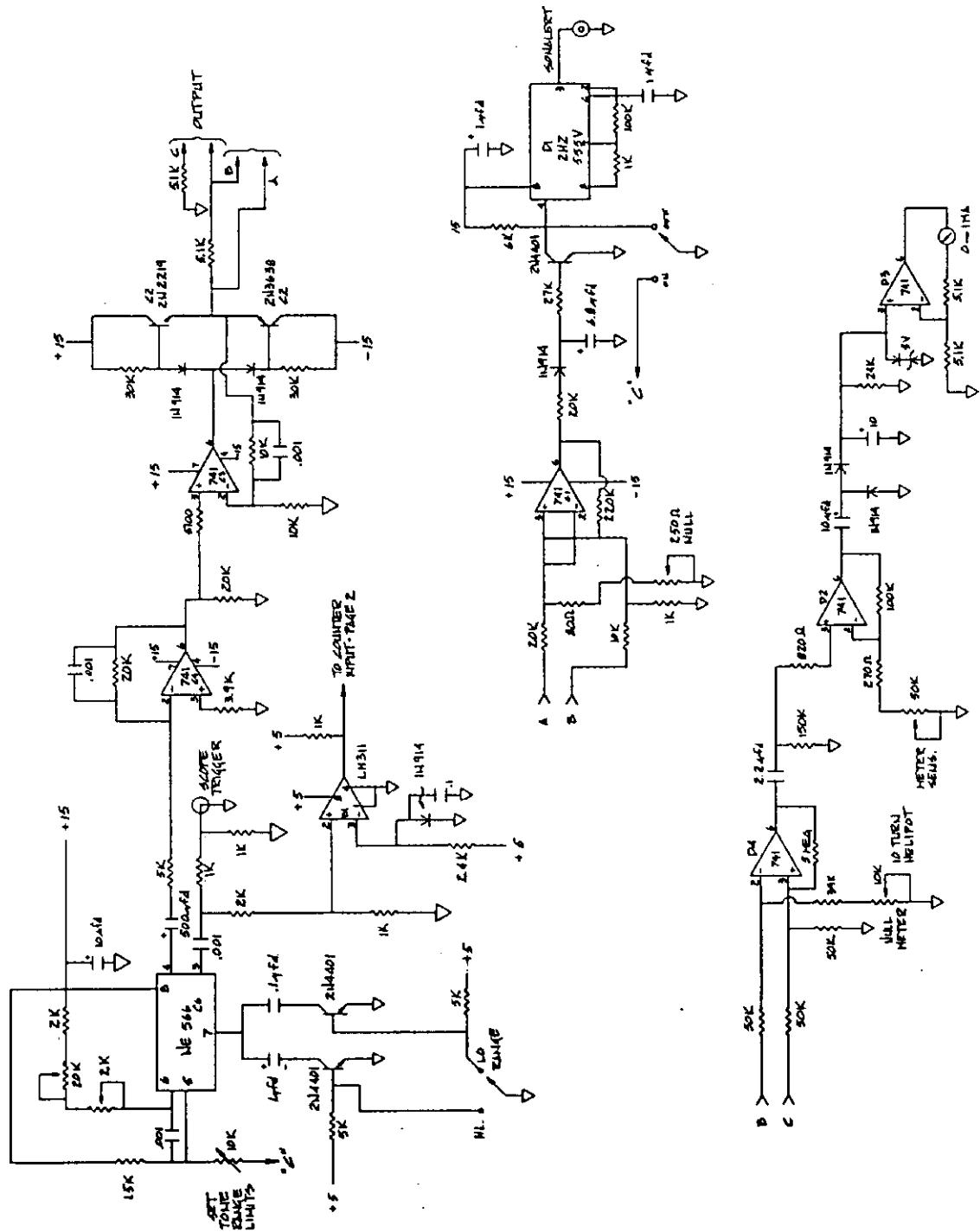
Set the frequency of the instrument approximately 20% away from the expected resonant frequency, carefully null the meter while increasing its sensitivity control until the meter reads roughly 20% of full scale. When the deepest null has been reached, move the frequency control in the direction of the expected frequency very slowly. As the resonant frequency is reached, there will be a noticeably sharp upward movement of the meter. Slowly tune through this region until the meter is peaked. This may take some time in chambers having wires as long as three meters as the time required to start mechanical oscillation in a magnetic field is noticeably longer than in chambers having wires in the one meter range.

The sensitivity is sufficiently great that the wire need not be in the gap of the magnet. Useful indications have been observed with a 10 Kg magnet nearly 2 cm away from the wire. Recently a magnet was used which projects its field away from the gap and this gave very good results. This eliminates totally the need to have the wire in the gap of the magnet.

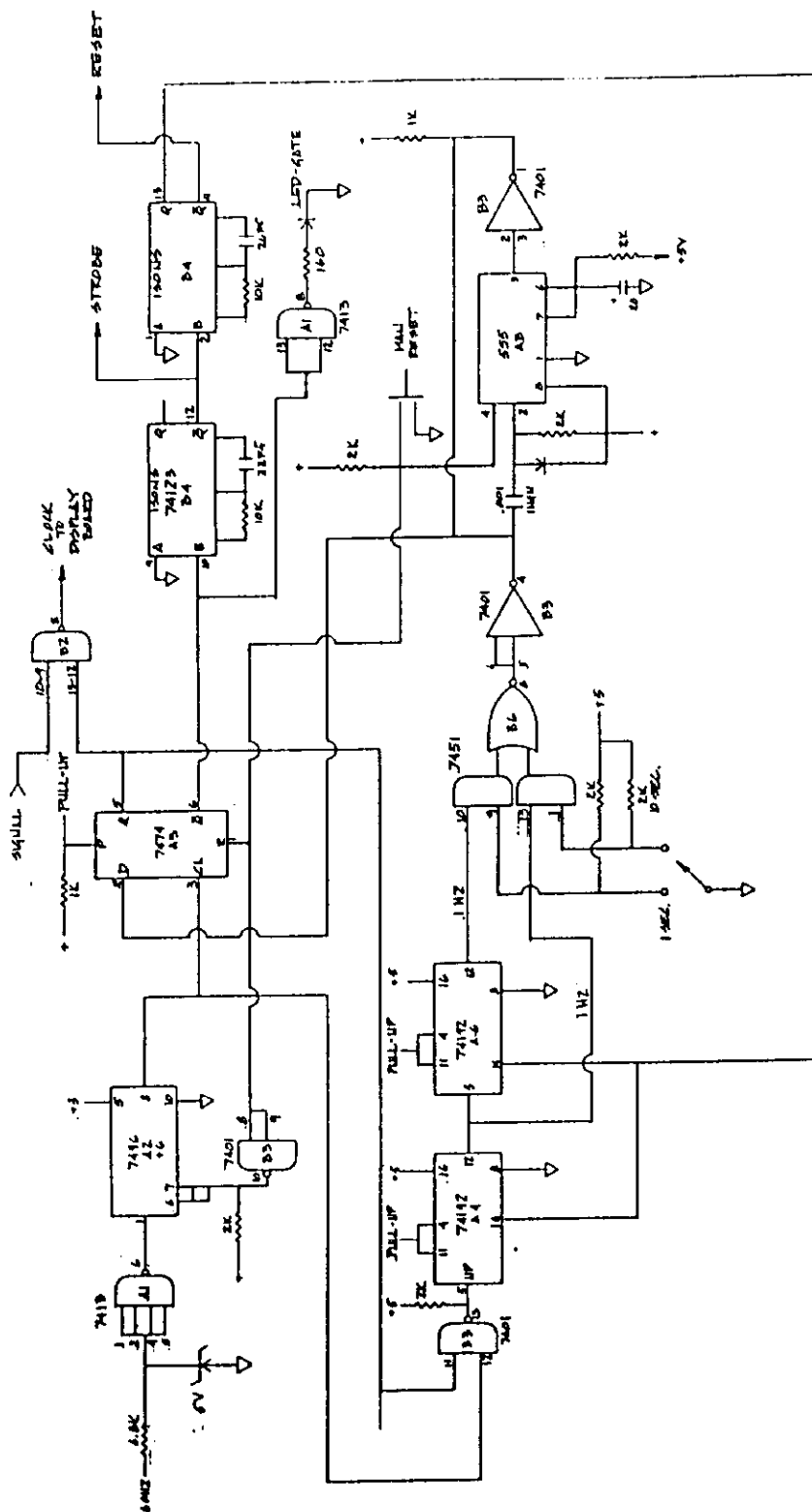
I wish to thank R.D. Kephart and L. Spencer for encouraging me to write this paper and for supplying background material and useful discussions. David Lloyd-Owen and K. Kephart are hereby thanked for helping in the preparation of this paper.

References

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2. K.B. Burnes et al., Nucl. Instr. and Meth. 106, 171 (1973); M. Cavalli-Sforza et al., Nucl. Instr. and Meth. 124, 73 (1975); A. Borghesi, Nucl. Instr. and Meth. 153, 379 (1978); R. Stephenson and J.E. Bateman, Nucl. Instr. and Meth. 171, 337 (1980); M. Calvetti et al., Nucl. Instr. and Meth. 190, 511 (1981).
3. M. Atac and M. Mishina, Fermilab TM-1125, CDF 133.

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